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MANUAL OF AGRICULTURE

FOR THE

PUBLIC SCHOOLS

State of Vermont

PREPARED BY

Prin. G. LELAND GREEN,
State School of Agriculture, Randolph Center, Vt.

Asst. Prin. LEO C. COOK,
State School of Agriculture, Randolph Center, Vt.

Mr. THOMAS J. ABBOTT,
East Bethel, Vt.

Issued by the Department of Education
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DEPARTMENT OF EDUCATION.

State of Vermont,

Montpelier.

My dear Fellow Teacher:—

On account of the increasing interest in agricultural education and the growing demand for helpful material, this pamphlet on Agriculture is issued. Most agricultural texts produced are either too general in their treatment of the subject or too foreign to local conditions to be serviceable. The great staple crops of the country and their extensive cultivation are usually treated, and the texts are, consequently, not applicable to the circumscribed and intensive agriculture that must be practiced in Vermont. Therefore it is hoped that this pamphlet may help to focus instruction in this important subject upon local and immediate conditions and methods.

It is foreseen that many of those who will attempt to give instruction in Elementary Agriculture have not received special training therefor, and hence will be compelled to give much study to the subject and much time to investigation. And so, not only to furnish helpful material, but to assist in avoiding aimless processes, fruitless experimentation and waste of time, this pamphlet is issued.

Agriculture, as an *economic* subject, is largely mathematical and is best adapted to those transition years between childhood and youth, or to the grammar grades of the elementary schools. It is applied arithmetic. But Agriculture, as a *scientific* subject, finds its rightful place in the secondary schools. All grammar grade pupils, especially those in the rural schools, can be and should be taught the business of a farmstead, such as the profit of a potato crop or a herd of cows, the cost of fencing a field or raising a colt, the increase of a timber tract or flock of sheep, the interest on an investment in hens or an orchard, the discount on machinery or fertilizer. But the *science* of Agriculture requires more maturity of mind, a capacity for analysis, an intelligence in experimenting, and power to make correct observations and

deductions. Hence, on account of the immaturity and limitations of the pupils, it cannot be profitably taught in elementary schools. On the other hand, it can be profitably taught in the secondary schools, for the reason that the students have reached the experimental and reflective period in life, a period in which they desire to know cause and effect, to find out the relationship of things and to discover the forces of life. In teaching scientific Agriculture, it must be remembered that it is not an individual science like physics, chemistry, mineralogy, geology, zoology or botany, each of which deals with a particular phase of the natural forces or phenomena, but it is a composite; it is a science of sciences, it deals with all phases and forms of physical nature. Because it is of this character it should not be taught as supplementary to the individual sciences, but as complementary; it should be the subject into which the individual sciences merge.

As Agriculture is Vermont's chief occupation, as it is the environment of most of the students in the secondary schools, as it is the source from which comes the large part of the revenue for the maintenance of the public schools, as it is the *sine qua non* of all industries and occupations, it has a feasible and legitimate claim to a place in the curricula of the secondary schools of Vermont.

The term Agriculture would better be confined to that phase of the subject presented in the secondary schools, and Nature Study to the preliminary work carried on in the elementary schools. This distinction in terms seems advisable on account of the difference in the nature of the child and in the character of the instruction to be given. The child in his childhood years epitomizes the human race in its struggle and growth. He is trying to familiarize himself with and adjust himself to his environment. Nature has fitted his budding mental powers for this. Observation and memory are at full tide. He sees objects and remembers names. He is accumulative. He gathers a vast amount of hetereogenous matter which he digests and assimilates later. Not only is this mass the natural material for the development of his powers of observation and memory, but his mental development by such means and material is necessary for future work and success.

Thus it will readily be inferred that a practical and profitable study of Agriculture is based primarily on Nature Study, both for material and for method of procedure.

Nature Study deals with the obvious, the concrete, the whole; rather than with the symbolic, the abstract, or the part. Nature Study is environmental; Agriculture is utilitarian. Nature Study considers objects in their natural relations; Agriculture considers them in their application. Nature

Study uses qualitative terms; Agriculture, quantitative terms. Nature Study deals with the processes of nature for her own ends; Agriculture deals with them for human ends. Nature Study is cultural; Agriculture is economic. In short, Agriculture is Nature Study plus human direction toward human ends. The grasses may be studied in their forms and growths as Nature Study; but when studied for the purpose of improving the quality or increasing the product, the subject becomes Agriculture. A stream may be studied in its course and cascades, in its volume and speed, as Nature Study; but when studied in its uses to man for various kinds of mechanical and domestic purposes, it comes within the realm of Agriculture. Therefore, on account of these differences in aim, methods and ends, it seems advisable to apply the term Nature Study to work in elementary schools, and Agriculture to work in secondary schools.

The genetic order is culture, economy, science, and this dictates the order in which the general subjects should be pursued.

Believing that more Nature Study in the elementary schools and more Agriculture in the secondary schools will enrich the courses and render school work more attractive and profitable, I remain

Very sincerely yours,

MASON S. STONE,

Superintendent of Education.

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INTRODUCTION.

A manual on elementary agriculture for use in Vermont schools,—one which shall consist of simple exercises, explanations and observations, one which requires only every day appliances, one in which each exercise is replete with question marks,—such a manual ought to be well worth while, and such the present issue is meant to be.

It is the product of several persons. The matter dealing with elementary forestry (exercises 58-66) is written by State Forester A. F. Hawes, while the remainder is the product of three graduates of the Agricultural Department of the University of Vermont, Principal G. Leland Green and instructor Leo C. Cook of the State School of Agriculture at Randolph Center and Thomas J. Abbott, of East Bethel. Mr. Green and Mr. Abbott contributed Exercises 1 to 26, 47, 67 to 70, while Mr. Cook furnished the matter dealing with plant life, Exercises 27-46, 48-56. Many of the exercises are furnished with references to state and governmental publications which, if in print, are free for the asking. A list of a few desirable books is given at the close of the manual.

Abstract from an address on "Agriculture in the High School" by the late President Matthew H. Buckham of the University of Vermont.

"Agriculture, in the new and broad sense which it now carries, is not only a cultural subject but a vital subject, one which touches universal life in so many ways, touches in so many essential and inevitable ways the life of every man, woman and child in the community, that to know of it what is to each one knowable is an obligation; that to be ignorant of it beyond necessary limitations of opportunity and capacity, is negligence and waste of life."

* * * * * * *

"The new agriculture which has to do with the new earth and to which every human being has such vital relation as to make the knowledge of it obligatory, and the teaching of it to every pupil the duty of public education—what is it? It is the science and the art which concerns itself with all man's relations to this physical globe, including the water within it and the air surrounding it. Arnold Guyot wrote a great epoch-making book on the ways in which the earth affects man. George P. Marsh, our greatest Vermont scholar, wrote a great book showing how man affects the earth. The new agriculture, considered as a topic in general education, partakes of both these views. Its postulate is that this earth which the Creator has given to the children of men, He has richly endowed

with capabilities which it is their province to discover and appropriate; that whereas in the past it has been the source to man of much toil, privation, disease, destruction, terror, it has countervailing resources which if wisely used would increase indefinitely man's health, wealth, energy, and enjoyment of life; that we have only begun to guess what it has in store for that coming race who will know how to use the new earth; that some time men will learn to 'replenish and subdue the earth and have dominion over it,' and to get from land and water and air, from heat and frost, from gravity and electricity, from wind and rain and tides, from all known and now unknown natural forces and agents, more and better food to eat, purer air to breathe, better clothing to wear, easier tillage, larger crops, better control of insect and bacterial life, better paper than that made from wood-pulp, a better berry than the strawberry, a better apple than the Northern Spy, a sweeter flower than the rose—in short, lightened labor, an ampler table, healthier dwellings, better education, and more time for it, larger and fuller and truer lives.

"'But this is much more than agriculture.' Yes, it is, but agriculture has more openings into this broader field than any other subject, and does in fact lead into it on all sides. Agriculture is not a simple science, but a group of sciences, each one of which is linked with all the others, so that you cannot know even a little of one without knowing something of others."

* * * * * * *

"In fact a little learning in any of the subjects with which agriculture deals convinces us that to know agriculture fully, is to know well nigh all that is knowable, and on the other hand to know and to teach any subject, however elementary, proper to agriculture, is to open a window which looks over some broad section of the new earth."

* * * * * * *

"I have spoken of agriculture in the High School only as a cultural study. But the study of it pursued in the spirit I have suggested, would actually be a vocational study to at least this extent: it would enable those who afterward follow agriculture as a vocation to choose it intelligently and deliberately, and not as an almost necessary incident of being brought up on a farm. It would do more than this, it would so present the possibilities of agriculture as to induce more of the vigorous and capable young lads of a rural community to choose it as their calling and to follow up these initial studies, with those more strictly vocational applications of modern science to agricultural art, which would put them in line with the great movement now advancing toward the full conquest of the new earth."

GENERAL OUTLINE OF EXERCISES.

Object:—Title of experiment.

Materials:—Different kinds of apparatus, (inexpensive and home made).
Material needed for experiment.

Directions:—

Observations:—Tabulate whenever possible.

Conclusions:—State everything on mathematical basis so far as possible.
Use percentages whenever possible.

SOILS.

Formation of Soils.

EXERCISE 1.

Object: To show that soil is largely of rock origin.

Materials: A few samples of soils; leaf mold.

Directions: Rub a pinch of each soil in the fingers; place it between the teeth. Note its gritty feeling. Compare with finely powdered rock; note both the likeness and unlikeness thereto. Place a handful of each on a hot stove and note the changes. Do all of these things also with leaf mold. The blackening is evidence of organic matter; the grittiness of rock origin. Drop soil into water. Note its insolubility.

Reference: Vt. Exp. Sta. Bulletin 143, pp. 199-202.

EXERCISE 2.

Soils are formed in many ways. Among the more important agencies are: air; water (acting chemically to dissolve and mechanically to rub and abrade); ice; life action.

Object: To illustrate the action of air and of heat and cold upon soil formation.

Materials: Any old stone building or old grave stones; any rock which has been etched by wind driven sand, or flaked by temperature changes; lamp chimney, fruit jar.

Directions: Note a pane of ground glass. How did it become opaque? In the desert, in semi-arid regions, on the seashore and elsewhere, sand driven by the wind wears away the rock.

Note the easy scaling off of the outside layers of many old rocks or stones, due to uneven expansion and contraction caused by temperature changes, (heat and cold). The breaking of a cold tumbler when boiling water is poured on it, or of a hot tumbler, stone or lamp chimney when ice cold water is dashed on it, illustrates this effect, although in an extreme way.

Note at the foot of cliffs the pile of rock fragments of uneven sizes. These usually fall because the pores and crevices in the face of the cliff fill with water, which expands in freezing, thus breaking off the masses which fall to the base of the cliff.

Illustrate by freezing water solid in a closed fruit jar.

References: Vt. Exp. Sta. Bulletin 143, pp. 205-209; Vt. Exp. Sta. Bulletin 154, pp. 715-716.

EXERCISE 3.

Object: To show the effect of gravity upon soil transportation.

Directions: Observe the results of landslides, of the down hill creep of soils in moist places; how fences once straight sometimes show curves in moist places. Why are valley soils richer than hill soils? What part does gravity play in this condition?

References: Vt. Exp. Sta. Bulletin 143, p. 214; Vt. Exp. Sta. Bulletin 154, p. 710.

EXERCISE 4.

Object: To illustrate the solvent effect of water in soil formation.

Materials: Limestone rock, glasses, salt, etc.

Directions: Observe in limestone regions, the caves, sinkholes, etc. caused by solution of the rock. Note the honey combing of limestone rock. Note the "fur" on the inside of an old tea-kettle. What is it? How did it get there? What bearing has it on this matter? What makes waters hard? What causes mineral waters? What makes iron rust? What

causes some soils to be red? Why are rocks in desert regions, etc. highly colored? And why are their colors mostly reds and yellows?

A heated water, or one containing carbonic acid gas, dissolves rock more readily than does cold or ordinary water. Take two glasses of water, one hot, one cold. Stir into each all the salt that can be dissolved. In which one can you dissolve the larger amount of salt? When the glass of hot water cools, what happens?

Reference: Vt. Exp. Sta. Bulletin 143, pp. 209-215.

EXERCISE 5.

Object: To illustrate the abrasive effect of moving water in soil formation.

Materials: A brook; a meadow; a pail of water.

Directions: Moving water is an active agent in rock destruction. Note the rounded, water-worn pebbles in the brook. Why are they all thus rounded? Note the effect of rain on the brook; on the loose soil on a hillside. Why does water become roily after a hard shower? Note the sorting of soil by streams. Illustrate by pouring a pail of water on the ground where the soil is loose. How are valleys formed? How are river meadows made?

References: Vt. Exp. Sta. Bulletin 143, pp. 216-229; Vt. Exp. Sta. Bulletin 154, pp. 710-715.

EXERCISE 6.

Object: To show the effect of moving water on soil transportation.

Material: A stream in freshet; a pail of water; a fruit jar.

Directions: Note the muddy appearance of streams in times of high water. Note the deposits where streams overflow their banks. Dip up a pail of water from a roily river or brook and let it settle. Examine the sediment and note in a glass fruit jar the way it is lain down in layers of different finenesses.

What is a river delta? Why are deltas formed? Why do valleys of most rivers widen toward their mouth? What makes great river plains like that of the Mississippi? Is the movement of soil by water harmful or helpful? Are these river muds apt to be fertile or sterile soils? If fertile, why?

This transportation of soil by water may be a good or a bad thing, according to circumstances; according to whether a soil is put into better location or a worse one, or whether it is carried to sea and lost. Note how man can control and modify these movements by controlling vegetation; by keeping the land clad with grass, or with forests. Note differences in the character of the waters running off from grass land or wheat land and from bare, unoccupied land. Why is the former usually clear and the latter apt to be muddy? Would a sandy or clayey soil be the more apt to be borne away by water? What relation has the slope of the land to the amount of water which runs off and the rapidity of its run-off?

References: Vt. Exp. Sta. Bulletin 143, pp. 219-229; Vt. Exp. Sta. Bulletin 154, pp. 710-713.

EXERCISE 7.

Object: To illustrate the abrasive work of ice in soil formation.

Material: A stony field; a glaciated landscape.

Directions: Outline the work of the prehistoric glacier. Use pictures of modern glaciers showing their work. Note glacial scratches on flat topped ledges. Observe glacial boulders, erratics, etc. Account for the multitudinous stones in New England soils. Describe the grinding effect. Why are New England mountains and hills rounded? Why is New England full of little ponds and lakes? Why are such not found South or West?

References: Vt. Exp. Sta. Bulletin 143, pp. 230-236.

EXERCISE 8.

Object: To show that plant life tends to form soil from rocks.

Materials: An old stone wall; a piece of marble.

Directions: Observe the effect of roots when they penetrate rock crevices. See how they tend to expand and to split the rock asunder. Observe the same action in hard soil. The expansive power of growing vegetation is almost beyond belief. A generation ago a squash was put into a harness at Amherst, Mass., and lifted nearly 5,600 pounds.

Scrape from an old stone wall a patch of lichens. Notice how soft is the rock directly underneath as compared with the

exposed rock. Note the number of lichens on a given length of old stone wall.

Put a smooth, polished piece of marble in a flower pot or tin can of earth and then grow grass, oats or some other crop in the pot in such a way that the roots must pass over the smooth surface. After a few weeks take out the piece, wash it off carefully and notice the tracery of the roots at the point where they ran over the smooth surface. Roots exude an acid which dissolves rock.

References: Vt. Exp. Sta. Bulletin 143, pp. 236-239.

EXERCISE 9.

Object: To show that animal life has bearing upon soil making.

Materials: An ant hill; a shovel wherewith to dig for worms.

Directions: Dig into the ant hill. Note the ramification of the galleries. Note the fine appearance of the soil. Note the immense number of workers. What effect does their activity have upon the opening up of the soil? What effect does the breath of the ants have upon soil solution? What effect does the decay of their bodies have on soil solution?

Set a boy digging for worms. Let him make an estimate of the number of worms in a given area. Note how the worms open up the soil. Note particularly on a rainy morning or after a rainy night, the castings of the earth worms on the sidewalk. These casts are simply the excreta of the earth worms, which eat soil and, along with it, much leaf mold. They use the latter for food and the former for grinding purposes. The soil is decidedly bettered as a result of its passage through their bodies.

References: Vt. Exp. Sta. Bulletin 143, pp. 239-242.

Classification of Soils.

EXERCISE 10.

Object: To indicate the differences in origin, formation, nature and uses of soils.

Materials: Samples of all the different kinds of soils to be found in the vicinity.

Directions: There are several different soil classifications formulated in accordance with the origin, characteristics, and usage of the soil.

(1) Classification according to origin shows whether the soil is a sedentary soil, that is to say, one derived from the rocks immediately underlying; or a transported soil, that is to say, removed from the place where the original rock lay. All New England soils are transported soils. Most of them are glacial or drift soils. See if you can find evidence that the Vermont soils are largely of glacial origin. Are Vermont soils uniform in thickness? Why are they stony? Do they appear to be of uniform composition? (See exercise 7).

Alluvial soils are those transported by running water and deposited in river valleys at stream mouths. They are more finely pulverized than are drift soils. Find examples. Are they fertile and well suited to farming purposes? (See exercise 6).

The classification according to characteristics is based upon the size of particles. Thus we have:

Stones,—Coarse, irregular or rounded rock fragments or pieces of rock.

Gravel,—Coarse fragments and pebbles ranging in size from an inch or so in diameter down to 1/25 of an inch.

Sand,—Soil particles ranging from 1/25 of an inch down to 1/ 500 of an inch in diameter. Sand may be divided into coarse, medium, fine and very fine.

Silt,—Fine soils ranging from 1/500 to 1/5000 of an inch in diameter. Silt feels very fine and smooth when rubbed between the fingers, especially when moist. Silicon used for scouring knives is a very good illustration of silt. Obtain a little at the grocery store and become familiar with it. Silt is sticky like clay when wet.

Clay,—The finest or rock particles, 1/5000 of an inch and less in diameter. Too small to imagine. Clay is very slippery and sticky when wet. Whiting and yellow ochre from the paint shop are good illustrations of clay.

Humus,—This is decaying vegetable and animal matter. It is dark brown or almost black in color; decaying leaves and woods are examples.

Soils composed of the above materials:

Sands or Sandy Soils,—These are mixtures of different grades of sand and small amounts of silt, clay and organic matter. They are light, loose and easy to work. They produce early crops and are particularly adapted to early truck and fruit, but are too light for general farming.

Loams are mixtures of sand, silt, clay and organic matter. Sandy loams are about three-fifths sand and two-fifths silt and clay. They are tilled easily and raise good corn, but are a little too light for general farming.

Clay loams contain more clay than anything else. They are hard to work, being stiff and sticky, but are considered the strongest soil for general farming. Gravelly and stony loams are not easily worked and are well adapted to fruit, forest and pasture.

Pure clay soils are generally too hard and sticky for general farming, but when they can be tilled they are specially adapted to hay, pasture, wheat and corn.

Swamp muck is a dark brown or black swamp soil consisting of large amounts of humus or decaying organic matter, mixed with some fine sand and clay. It is found in low, wet places.

Peat is also largely vegetable matter, consisting of tough roots, partially decayed leaves, moss, etc. It is quite dense and compact and in some regions is used for fuel. When subjected to further heat and pressure, peat becomes coal.

Classification in accordance with usage deals with corn soils, grass soils, potato soils, wheat soils, etc. This might be termed the farmer's home-made classification.

For a full discussion of soil classifications, see Vermont Experiment Station Bulletin 154, pp. 706-732.

Make collections of all the different kinds of soils about your school. Use small bottles for receptacles and label each soil carefully.

References: As above; also Ohio Sta. Circ. 39; U. S. Dept. Agr. Bureau of Soils, Bulletin 55, "The Soils of the United States."

Soil Physics.

EXERCISE 11.

Object: To show pore space in general and pore space in soils in particular.

Materials: Samples of various soils, rock or pebbles; tumblers, fine cloth.

Directions: Fill a tumbler or other clear glass dish with pebbles and note the spaces between the pebbles. Pour in water to fill the spaces, measuring the amount required. Repeat the experiment with each of the different soils, both loose and compact, tabulating the results. (With the clay consider-

able time will be required for this exercise, which must be done carefully or the results will be entirely misleading.) What was in the spaces before the water was poured in? Tie a piece of fine cloth over the top of each vessel and turn it over, allowing the water to run out into a dish. Measure the amount that runs out in each case; in five minutes, in one hour, and in twenty-four hours, comparing with the amounts poured in at first. (The latter part of this exercise illustrates the water-holding power of soil of different kinds.)

EXERCISE 12.

Object: To show that soils contain air.

Materials: A few flower pots or tin cans, several kinds of soil.

Directions: Fill a flower pot or tin can with soil and press it down fairly tight. Now submerge it in a pail of water. Note that air bubbles rise from the soil, proving that the soil contains air.

Take equal volumes of clay, sand and humus in three small cans. Add water in each case until it comes to the surface of the soil. In which case is the most water used? Does the volume of water indicate roughly the volume of air in the soil? Figure out the percentage of air space in each of these soils. This you can do if you have used measured amounts of water and of the soil, using the rule of proportion.

EXERCISE 13.

Object: To show that soils are composed of particles of various sizes.

Materials: Samples of as many different kinds of soils as can be found in your vicinity.

Directions: Having collected the samples of sand, loam, clay, peat, muck, etc., place a handful of each in a jar and shake well, pouring off the water after a minute's wait. Slowly evaporate this residue to dryness, meanwhile allowing the muddy water to settle for, perhaps, an hour. Then, pour off the clear portion. Compare the dried residues from each soil, which will be essentially sand, silt and clay. Note the varying proportions of each in each soil. The loam will be found the best soil thus to study, as it is the most even mixture of the various soil particle types. Study the different types of soil. Compare them as to color, size of particles and consist-

ency and behavior when wet and when dry. Note the kind and appearance of plants growing on each.

Why should the first dried residue be of coarser particles than the second, and the second coarser than the material remaining suspended in the muddy water? Why should soils differ in type, color and in size of particles? Why do clays wet readily and sands wet much more slowly? Why do differences occur in the temperatures of different soils? Why does grass grow better on clay loams than on sandy loams and corn better in a sandy region than on clay?

EXERCISE 14.

Object: To show the different temperatures of different soils.

Materials: Samples of soil, lamp black or soot, chalk, piece of black cloth, piece of white cloth, boxes.

Directions: Soil temperatures depend primarily upon their texture, color, slope, moisture content and cultivation. Soils of a sandy texture, of a dark color, on side slopes and relatively dry, warm up more readily than do their well moistened and shady opposites. This is not saying, of course, that the light colored soil on a south slope might not be warmer than the dark colored soil on a north slope. In other words "circumstances alter cases", and the dominant condition determines the outcome.

Place a band of black cloth and one of white cloth around the bare arm at the same time. Go out into the sun. Note if there is any difference in the warmth under the two bands. Apply the results by reasoning to black soils and to light soils.

Take two boxes of soil of the same character; cover one with a thin layer of lamp black, cover the other with a thin layer of chalk. Set the two boxes in the sun. If a thermometer is available, take the temperature of the two soils. Feel of the soil in the two boxes and note differences in temperature, if any. Why should one soil be warmer than the other? What color of clothes does one wear in the winter? What in the summer? Why? What does black do to heat rays that white does not? Why?

Fill two boxes, one with sandy soil and one with clayey soil. Expose them to the sun at the same time. Note which is the warmer. When you go in bathing was the sand on the beach hotter than was the ordinary soil? Was it hotter than the water? Why? Which warms up the faster? Which cools down the faster? What relationship has the large

amount of water which the clay holds to its being cooler than the sand?

Set two boxes of soil in the sun, one quite wet, the other dry. Which is the warmer? Why? Put a little alcohol, ether, or gasoline on the back of your hand. Why is it cold?

Take two boxes of the same kind of soil and so place them that the rays of the sun strike one vertically, and the other at a considerable slant. After an hour or two use a thermometer and determine which is the warmer. Why is one of these warmer than the other? Why are the tropical regions warmer than the temperate regions? Why is summer warmer than winter? Make a diagram showing how the sun's rays strike at the equator and at the poles, and on these boxes.

Having made all of these trials, list them all and bring together the factors that influence soil temperature.

EXERCISE 15.

Object: To show the percolation, or downward passage, of water.

Materials: Lamp chimneys, soils, cheese cloth.

Directions: Fill a lamp chimney closed at the bottom with a tightly tied piece of cheese cloth, with some one of the soils to be tested. Similarly fill other lamp chimneys with the other soils. Pour water upon the top of each column of soil and note the percolation of the water through it. Pour the water either out-of-doors or over a pail or sink, in order to lessen the likelihood of damage from slopping. Does the water stay in the tubes? In which one does it pass through the most quickly? In which one the least quickly? Compare the various kinds of soil in this respect. Measure the amounts of water percolated through each chimney in a half an hour.

Pour a pail of water on the ground in a level place. Where does it go? What can you say about the power of sand to hold the rain which falls upon it? Its power to take up moisture from below? Why is it well to run the roller over a sandy soil? Why is the water more likely to run off the surface of a clayey soil than of a sandy soil? How may the clay be opened (compare exercise 22)? What may be done to the sand to make it hold the water better?

EXERCISE 16.

Object: To show that water rises by capillarity from below upwards. To illustrate the way soils take up moisture and the distance it can rise.

Materials: Lamp wick, blotting paper, lump of sugar, samples of soils, lamp chimneys, cheese cloth, pans.

Directions: Place the pieces of lamp wick, blotting paper and the lump of sugar so that one end of each just touches the surface of either water or ink. Note carefully what happens.

Take as many lamp chimneys as you have samples of soil. Tie a piece of cheese cloth over the end of each. Then fill them with clay, sand, fine peat and the various other soils that are at hand, one soil to each chimney. Place the chimneys, cheese cloth end downward, in a pan containing about an inch of water. Note the differences in the rate and extent of rise in, one hour, one day, two days and longer. Note in which the water rises highest. Why does it rise highest? Note which rises quickest? Why does it rise quickest? Is the chimney in which the water rises quickest, the one in which it rises highest?

Capillary attraction draws liquids upwards in small tubes. The smaller the diameter of the tube, the higher the liquid may rise. Which soil contains the smallest pore spaces or tubes? What is the object of compacting soil over seeds? Which soil will draw water up most easily? Which will pull water the fastest from below?

After this experiment has been completed, fill some tubes half full of soil and put in a handful of green grass or cut straw, then fill up with soil. Set the tubes in water again and note the results compared with the first trial. Explain the particular bearing of this trial upon the plowing under of the grass. Repeat, using well decayed manure. Compare with exercise 21.

References: Vt. Exp. Sta. Bulletin 123, "The Moisture Relations of the Soil."

EXERCISE 17.

Object: To show the absorptive powers of various soils for water.

Materials: Sand, clay, loam, leaf mold, five tin cans each holding water, with holes in the side and with a string for a bail; spring balance.

Directions: Fill a can two-thirds full with dry sand, another with clay, another with loam, another with mixed clay and leaf mold, another with mixed sand and leaf mold.

Wet each one and water each one until thoroughly wet, drain fifteen minutes and record results as follows:

	Sand	Sand and leaf mold	Loam	Clay	Clay and leaf mold
Weight of can					
Weight of can and soil					
Weight of soil					
Weight of both with water					
Weight of water					
Percent of water					

The last moisture column, the percent of water, of course, will be calculated by dividing the weight of water by the weight of soil. Which soil absorbs the most water? Why? Which the least? Why? What relationship has this trial to the practical handling of soils in crop growing?

Dip a pebble in water. Note how the water is held upon it as a film. What effect would the breaking of a pebble have upon its water holding capacity? If it was broken into two pieces? Into four pieces? Into forty pieces? Into four thousand pieces? Why does sand hold less water than clay? What effect upon the water capacity of a soil has the condition and amount of its organic matter? What is organic matter? If you should dip a piece of bread and a pebble into water, what difference would you observe in the manner in which the water is held? Note that organic matter, typified by the piece of bread, becomes soaked, while inorganic matter, typified by the pebble, does not. Will a sponge, which absorbs water, hold more than a rock, which simply has a film upon it?

Since plants obtain their food by absorption from the soil solution, and since the film of water which surrounds the soil particles absorbs this food, what effect has the thorough tillage of soil upon the amount of water absorbed? Which dissolves the quicker in a cup of coffee, two lumps of sugar or two teaspoonfuls? Why? Why has the old adage "tillage is manure" validity? How do plants get their food from the soil?

EXERCISE 18.

Object: To show how roots take moisture from the soil.

Materials: An egg, a candle, a small glass tube three inches long and one-quarter inch wide, a wire, a bottle.

Directions: Remove a part of the egg shell the size of a nickel from the large end without breaking the skin beneath. This is easily done by gently tapping the shell with the handle of a pocket knife, picking off the small pieces. Similarly remove the shell from the small end over a space about as large as the end of the glass tube. Cut a piece one-half inch from the lower end of the candle, and bore a hole just the size of the glass tube. Now soften and then fasten one end of the piece of candle with the hole in it onto the small end of the egg in such a manner that the hole in the candle comes over the hole in the egg. Heat the wire and with it solder the piece of candle more firmly to the egg, making a water tight joint. Place the glass tube in the hole in the candle, pushing it down till it touches the egg. Then, with the heated wire, solder the tube firmly in place. Now run the wire down the tube and break the skin of the egg just under the end of the tube. Fill the bottle with water till it overflows and set the egg on the bottle, the large end in contact with the water. In an hour or so the contents of the egg will be seen rising in the glass tube. This happens because the water is making its way by osmose into the egg through the skin, which has no openings, so far as can be discovered. If the bottle is kept supplied with water as fast as it is taken up by the egg, almost the entire contents of the egg will be forced out of the tube.

In this way water in which plant food is dissolved enters the slender root hairs and rises through the plant.

EXERCISE 19.

Object: To show the effect of mulching and of cultivating soils.

Materials: Half a dozen ten pound sugar pails or similar vessels, lamp chimneys, various soils numbered from 1 to 6.

Directions: Fill each sugar pail within two inches of the top with loam. Slowly pour in water in equal amounts on each pail, a small cupful at a time, until the soil is well moistened, but not flooded. Or, as an alternative, mix up all the soil before putting into the pail with water for uniform moisture content. Leave No. 1 untouched after it has been moistened; on No. 2 place a layer of straw or sawdust an inch deep; on No. 3 a layer of dry dust an inch deep. Stir No. 4 daily to a depth of one inch; No. 5 daily to a depth of two inches; No. 6 daily to a depth of three inches. Set them all together in a row under the same temperature, light and air conditions. At the end of two weeks empty out the soil from each pail and

compare the soil and moisture conditions. If scales are available, weigh each pail of soil at the beginning and again at the end of the trial. In case you make weights, tabulate your results carefully and make comparisons, you will find differences in these weights before and after treatment. Which pail has lost the most and why? What did the layers of dust and sawdust and the stirring accomplish? Of the three which have been stirred, what one has lost the most moisture and why? Can you control the rate of evaporation? Is it desirable to control this rate? Which of the various methods used give the best results and which is the most practical on a large scale?

What is evaporation? Fill two dishes of equal size with water, put one on the stove and the other on a table or desk where it may remain for a number of days. What becomes of the water in the dish placed on the stove?

Wet the back of one hand keeping the other dry. Swing both hands briskly in the air. Is evaporation equal to temperature?

References: Vt. Exp. Sta. Bulletin 123, "The Moisture Relations of the Soil."

EXERCISE 20.

Object: To show whence the dew comes.

Materials: Pitcher of ice water, sheet of glass or tin.

Directions: What is dew? Whence does it come? Set a pitcher or glass of ice water in a room and watch it for a few moments. Note where the dew is heaviest in the morning. Place a piece of tin or window glass horizontally just above the grass during the growing season and look at both sides, top and bottom, in the morning. Does all the dew fall or does much of it rise? Repeat this exercise, placing the glass or tin very closely to the surface of the soil, surrounding the surface with glass, tin or oiled paper, so that if any water appears on the surface of the glass, it must come from the soil.

How could there be water in a soil that appears to be so dry? Is its passage from the dry soil an advantage or disadvantage? If the latter, can it be lessened? Is the relationship between capillarity and evaporation a help or hindrance to the farmer who understands it? What is the law of condensation of water vapor? Does it condense on a cool or warm surface?

References: Vt. Exp. Sta. Bulletin 123, "The Moisture Relations of the Soil."

EXERCISE 21.

Object: To illustrate the effect of plowing manure under.

Material: Two lamp chimneys, a quantity of dry fine soil, some finely cut straw or chaff, some well rotted straw and manure.

Directions: Tie a cloth over the bottom of each chimney. Fill the chimneys three-quarters full of soil. In one, put an inch of cut straw, pushing it well down together. In the other, put an inch of the rotted straw, likewise pushed down. To each add more fine soil, filling each chimney. Set each chimney in a pan in a half inch or more of water. Allow it to stand for several days.

Note the rise of the water. Does it pass through the straw as quickly as through the rotted material? Why?

The straw and rotted material represent material plowed under, lying in the bottom of the furrow. The soil on top represents the furrow slice. Apply the lesson of this experiment to farm practice. In which condition do you think a crop would suffer least from dry weather? When should strawy manures be plowed under? When should new ground be broken up? Should spring or fall be chosen for these purposes? Why?

EXERCISE 22.

Object: To show that humus and lime have favorable effects upon clay soils, flocculating, opening, mellowing them.

Materials: Clay, humus, lime, two glasses of water.

Directions: Take three equal portions of clay. Wet them thoroughly. Mix with one portion a considerable amount of humus or leaf mold, with another a small amount of lime, leaving the other alone. Make each of these into a mud ball or a mud pie and put them away to dry. On the following day examine each of them. Which is the more mellow? Which crumbles in the fingers the more readily?

Put a teaspoonful of fine clay into each of the two glasses of water. Stir them or shake them very vigorously. To one add a pinch of lime. Allow them to stand for an hour. Which settles the quicker? Why?

Lime tends to flocculate clays, i. e. to gather the fine particles together into larger particles. Humus tends to open up and make clay more porous. What is the object of making a clay soil mellower, more workable? What are the faults of clay?

References: Vt. Exp. Sta. Bulletin 99, (Limes and Lim-

ing); Vt. State Com. Agr., Farmers' Week Bulletin (Article on Limes and Liming); Do. Second Annual Report, (Ditto); U. S. Dept. Agr., Farmers' Bulletin 77, on "The Practice of Liming"; Vt. Exp. Sta. Bulletin 135, "Soil Deterioration and Soil Humus."

Soil Chemistry.

EXERCISE 23.

Object: To familiarize the student with the common elements of plant food.

Materials: Water, charcoal, flowers of sulphur, sand, lime, salt, magnesium ribbon, a piece of iron, a piece of aluminum ware.

Directions: If a chemical laboratory is a part of the school equipment, the teacher should demonstrate oxygen, hydrogen, nitrogen and show phosphorus, chlorin, potassium, sodium, as well as the other elements concerned in plant feeding. Some can be shown, however, without the chemical laboratory. Water is composed of 2 gases, hydrogen and oxygen. It may be decomposed into these gases by an electrical current. Charcoal is an impure carbon; so is ordinary coal. The diamond is a pure carbon. Burn a match. Why does it turn black? Sulphur is a yellowish material which will burn with choking vapor. Strike an ordinary match. It is the sulphur which burns with the blue flame; it is the sulphurous acid which causes the choking fumes. Sand is a combination of silicon and oxygen. The ordinary salt of our table is a combination of the metal sodium and yellowish green gas, chlorin. Lime is made up of the metal calcium and the gas oxygen. Magnesium ribbon and the piece of aluminum ware are pure, or nearly pure, metals, as is also the iron.

Plants use 14 or more elements,—4 derived from the air (hydrogen, oxygen, nitrogen, carbon), and 10 derived from the soil (silicon, phosphorus, chlorin, sulphur, potassium, sodium, calcium, magnesium, iron, aluminum).

Reference: Vt. Exp. Sta. Bulletin 99, "Deficient plant food."

EXERCISE 24.

Object: To illustrate the way humus is formed in soils.

Materials: A decaying tree trunk, loams, sandy soil, peat or muck.

Directions: The larger proportion of soil is made up of disintegrated rock structure. However, all soils contain more or less organic matter in a more or less state of complete decay. This decaying and decayed organic matter is known as humus, and furnishes a large share of plant food for plant growth. The decaying of organic matter and the formation of humus are brought about by bacteria, fungi and molds. The conditions which favor their rapid growth and active work are moisture, warmth, darkness and the presence of organic matter for food. It is by the death and decay of plant structure that in the course of time a thin film of organic matter is formed each year. In the course of ages this film becomes thicker so that it will support the largest trees.

Note the decaying tree trunk. Note the successive steps in its destruction from the unchanged wood to the completely broken down structure.

Note the obvious differences in appearance between sand, clay, loam and muck. Put a handful of each upon a hot stove and note that sand and clay do not blacken while the loam and muck do. The blackening is due to the burning or charring of humus or organic matter. Take five tin cans; in one place sand, in the next clay, in the next peat or muck, in the next loam, in the next a mixture of clay, sand and muck. Grow in each of these a small crop like oats or wheat. Water each one and notice the difference in the growth in favor of those cans containing humus.

References: Vt. Exp. Sta. Bulletin 135, "Soil Deterioration and Soil Humus."

EXERCISE 25.

Object: To show how soils may be tested for acidity.

Materials: Samples of soil, some rain water, litmus paper strips (red and blue), vinegar, lemon juice or other acid, ammonia, lime water, potash, or strong suds made from washing powder.

Directions: Soils sometimes become sour through the accumulation of acid. This more commonly occurs in low lands and swamps than elsewhere, where it can be remedied by drainage; but it also occurs in uplands. Acidity is injurious to most crops. It is often the principal cause of clover failure. The presence of injurious proportions of acid may be detected by the use of litmus paper and may be corrected by the addition of lime, using from 500 to 2,000 or more pounds per acre.

Put a small piece of litmus paper of each color in each of the above fluids. Note what happens. Note the distinction between acid, alkaline and neutral. Pour a little vinegar into diluted ammonia in which is floating pieces of the two litmus papers. Note what happens. See if you cannot so mix them that the paper will be just on the border line, neither red nor blue. When red, the fluid is acid; when blue, alkaline; when on the border line, neutral.

Get soils from different places. Take a handful of each and make a rather thick mud pie by using rain water or some absolutely neutral water. With a perfectly clean knife, preferably rinsed before using in some of this water, make a slash in each pie, put in a piece of litmus paper, (do not touch with the fingers as the fingers are apt to be acid), close the slash on the litmus paper, leave it for 4 or 5 minutes, re-open the slash and take out the paper. Rinse it if necessary in some of the rain water. Notice if the color is distinctly changed. If it has become distinctly red, the soil is acid. If it becomes more blue, it is probably alkaline, which is a common situation in this part of the country.

Carefully note the kind and appearance of plants growing on distinctly acid soils and upon the neutral soils. Learn to know the calciphiles (lime lovers) and calciphobes (lime haters). See page 102 of Vt. Exp. Sta. Bulletin 99 in this connection. Select a plot where the soil is distinctly acid and seems to be fairly even in character. Divide it into three parts; on one of these put lime, or marl, or ground limestone, or land plaster, on another put wood ashes, leaving the third untreated. Sow clover seed on all three plots and note the results. If any farmers in your vicinity use lime or plaster or wood ashes or marl, find out the results.

References: The same as to exercise 22.

EXERCISE 26.

Object: To show how to make a judicious choice of a fertilizer.

Materials: Samples of crude stock for making fertilizer (nitrate of soda, sulphate of ammonia, tankage, ground bone, acid phosphate, muriate of potash); samples of mixed fertilizers; a clean fertilizer sack.

Directions: Study the matter in the current fertilizer bulletin of the Vermont Experiment Station under the head of "the relation between selling price and valuation." Note:

1. That the cheaper the goods the more the plant food they contain costs.

2. That the higher grades usually purvey the most plant food for a dollar invested.

Study crop needs. Learn that foliage crops use nitrogen largely; grain crops, phosphoric acid; fruits and many vegetables, including potatoes, potash; not to the exclusion of other forms of plant food, yet preponderatingly. Learn what nitrogen, phosphoric acid and potash are.

Study soil origin and needs. Note that sandy soils are usually poorer than clay soils; that the latter need more potash than the former.

Consider the advisability of buying your nitrogen in the form of clover and alfalfa seed (thus gathering nitrogen from the air); and in the form of concentrated feeds for cows (cottonseed and linseed meals, distillers and brewers dried grains, wheat offals) rather than in fertilizers.

Bearing in mind the relative high cost of cheap fertilizers; having soil and crop needs in mind, and having bought nitrogen in part as above; choose your fertilizer accordingly, using as guides the guaranty of the manufacturer and the analysis of the Experiment Station.

Study the fertilizer bag and the Station bulletin. Learn what the guaranty means. Read the statement made in the bulletin about guaranties.

Compute the "valuation" of a fertilizer by multiplying the percentage of nitrogen, of soluble, reverted, and insoluble phosphoric acids, and of potash by the "trade values" of the year, and multiply by 20 to put on a ton basis. Compare with selling price. Find how many cents' worth of plant food are sold for a dollar. Directions are found in each year's fertilizer bulletin. Have each scholar find out what fertilizer is used at home; determine whose father has made the best purchase.

Make, if practicable, school garden trials with various fertilizing materials. Apply to Dean of the Agricultural Department of the University of Vermont for directions and suggestions.

References: Vt. Exp. Sta. Bulletins 99, (Concerning Fertilizer Buying: Plant Food); 116 (How, when and what to use for commercial fertilizers); 143 (The service of a fertilizer control); Circular 7 ("Plant Food Combinations"); and the current issue of fertilizer bulletin.

PLANT LIFE.

Seed Germination.

EXERCISE 27.

Object: To study the process of germination in a general way.

Materials: Common dinner plates or tin pieplates; pieces of cloth or filter paper, fourteen by seven inches; porous germinating cups are the best when available; a dozen large beans (Lima beans are excellent for this purpose) and a dozen kernels of corn for each student.

Directions: Examine dry beans and corn and then compare with some which have soaked in water over night. Diagram cross and longitudinal sections of each (x2) at different stages, (a) soaked a few hours, (b) when caulicle first pierces seed coats, (c) when caulicle is one inch long; labeling cotyledon, caulicle, plumule, seed coats and endosperm. Write a short description of germination in bean and corn comparing whenever possible. Answer the question as completely as you can:—What conditions are necessary for germination?

EXERCISE 28.

Object: To determine if moisture is necessary for germination.

Materials: Four cigar boxes, dry sand and forty beans, peas, or corn kernels.

Directions: Two days before planting of seeds fill boxes with sand, jar lightly, level and dry thoroughly. Divide seeds into lots of ten and weigh. Plant ten seeds in each box, one-half inch deep. To two of the boxes add water and keep sand moist, while sand in others is kept dry. Label each box keeping all in warm place. Leave until the seedlings in two of the boxes appear just above soil surface. Remove seeds from each box, examine, weigh and find percent increase or decrease. Write conclusions. Tabulate results.

EXERCISE 29.

Object: To determine if heat is necessary for germination.

Materials: Same as for Exercise 28, with the addition of ordinary thermometers. (Comparative results may be obtained without the thermometers).

Directions: Fill boxes with sand as in exercise 28; plant ten seeds in each box and keep moist. Place two boxes near stove or in some warm place in room. The other two boxes may be placed where it is not too cold. Sink thermometer bulbs in sand to depth that seeds are planted in each of the boxes. Read thermometers daily, both forenoon and afternoon, and tabulate results. Leave until seedlings appear in two boxes. Remove seeds from all boxes and examine. With advanced students this experiment may be carried out to find maximum and minimum germination temperatures.

EXERCISE 30.

Object: To determine effect of light upon germination.

Materials: Sand, glass tumblers, beans, corn, peas, squash, etc. In some schools, boxes with one side made of glass may be obtained.

Directions: Plant seeds next to glass, so that they can be observed, place some in dark closet or cellar and some in strong light. Record when plantlets appear and note any differences. Grow plants in dark and in light for a considerable period and compare. For checking experiment, plant some seeds in centre of tumblers and observe.

EXERCISE 31.

Object: To determine effect of air upon growing seeds.

Materials: Saucers, boxes or tumblers, clay, various kind of seeds.

Directions: Fill one saucer or box with clay loosely packed, and one with clay that has the consistency of putty. The putty condition of clay may be obtained by working the clay in the hands with water. Plant ten seeds in each. Press the putty clay tightly over the seeds. Cover each with glass to prevent too rapid drying, place in warm window. At the end of three or four days examine and record results.

EXERCISE 32.

Object: To determine if the vitality of seeds depends upon size.

Materials: Germinating plates and cloths like Exercise 27, corn, oats and other seeds.

Directions: Pick out twenty large and twenty small seeds of beans, corn, oats, radish, etc., and place between moist cloths. Examine frequently and note relative quickness in germination of the two different lots. Record in tabular form and reckon in percents of total germination and amount of germination at different times.

(Note—The Exercise may be extended by planting seeds in soil and measuring seedlings from time to time. Radishes grown in school garden from large and from small seeds may be observed for comparison in regard to crop production, if time permits).

EXERCISE 33.

Object: To determine if the vitality of seeds depends upon age.

Materials: Germinating plates and cloth as in Exercise 27. Seeds of beans, corn, peas, lettuce, etc., of different ages.

Directions: Have each student take twenty-five seeds each, of as many different lots, of as many different ages as possible. Place seeds upon moistened outing flannel between dinner plates. Note first germination and each day count all others. Record and tabulate, finding percent of total germination.

EXERCISE 34.

Object: To determine if the vitality of seeds depends upon color.

Materials: Plates and cloth as for Exercise 27. Seeds of beans, radish, peas, etc., in good quantity.

Directions: Select ten well colored seeds of each kind and ten dull or light colored seeds. Place upon moistened cloths between plates for germination. Note number of germinations each day, tabulate and find percent of total germination. Ascertain cause in all cases of germination failures.

EXERCISE 35.

Object: To find the length of time required for healthy seeds to germinate.

Materials: Plates and oblongs of cloth. Seeds of all common garden vegetables.

Directions: Have students take lots of twenty-five seeds each of two or three different kinds of seeds; place upon moist

cloth between plates, and record daily germination. Ascertain first germinations and average length of time required, recording different conditions under which experiment was performed (temperatures, etc). From all the reports, make table showing length of time required for germination, and have each student preserve copy in note book.

EXERCISE 36.

Object: To find out if the cotyledons of a seed are of any use.

Materials: Peas or beans, large perforated corks.

Directions: Sprout several peas or beans on blotting paper or damp sawdust and when the plumules appear, cut the cotyledons away very carefully, taking care not to injure the plumule. Place these on a perforated cork together with others not mutilated, allowing the caulicles to extend into a jar of water. Let them grow a few days and record results.

See Bergen, Elements of Botany, Fig. 7.

EXERCISE 37.

Object: To determine if there is difference in germination of corn from various parts of the cob.

Materials: Box four inches deep and twelve inches square filled with clean sand; an ear of corn and a foot rule.

Directions: Take an equal number (ten to twenty-five) of seeds from the tip, the middle and the butt of ear. Plant in separate rows, cover evenly and water from time to time. Note and record time plants are one inch in height, and measure height each day for two weeks. Average the growth of individual plants of each lot.

Carry out the same trial in garden and tabulate results of growth and yield.

EXERCISE 38.

Object: To determine the relative purity of various grain and grass seeds.

Materials: Seed oats as put out by dealers, clover seed. Various grass seeds may be used for advanced work. A hand lens is very useful, although not absolutely necessary.

Directions: Secure price of each sample and name of dealer. Run duplicate tests of each sample. Each sample should be thoroughly mixed by turning back and forth on a

sheet of paper. Weigh out three grams (one dessert spoonfull), spread on white sheet of paper. Separate the seed into three piles; (1) good plump seed; (2) weed seeds; (3) chaff, dirt, broken and shrunken seed, etc. Weigh each lot if scales are available and identify the weed seeds. Record results of whole class and place in note books. Find percent of good seed for tabulation, cost per bushel, cost per bushel of pure seed and number of weed seeds per bushel.

References: Vt. Exp. Sta. Bulletins 94, 146; Farmers' Bulletins of the U. S. Dept. Agr. 123, 260, pp. 3-6; Mass. Exp. Sta. Bulletin 121.

Plant Growth.

EXERCISE 39.

Object: To determine the best depth for planting various seeds.

Materials: Box of soil, olive bottles eight inches high or Mason jars so plants may be observed. Twenty seeds each of beans, peas, corn, clover, oats, etc.

Directions: Plant two seeds of each kind at depths of ½, 1, 2, 3, 4, 5, 6 inches. With a large class divide the work and give each different kinds of seeds. Put a little soil in bottom and six inches from top plant seeds, put in another inch of soil and plant seeds until jar is full, arranging seeds in a spiral fashion. Wrap black cloth around jars to exclude light. Record date at which each comes up and tabulate results from whole class.

Depth planted	Corn	Wheat	Beans	Peas	Radish
½ inch	.....	.....	.....	.....	.....
1 inch	.....	.....	.....	.....	.....
1½ inches	.....	.....	.....	.....	.....

Note vigor of plants planted at various depths. Which should be planted deeper, peas or beans, and why? One rule is to cover those seeds which bring up their cotyledons with five times their thickness of soil and those which do not bring up their cotyledons with ten times their thickness. Why this difference? In what ways does the temperature, character of soil and amount of moisture influence depth of planting? What is the purpose of rolling or "planking"? Is it more desirable with large or small seeds? In a wet or dry season?

References: U. S. Dept. Agr.; Farmers' Bulletin 218, page 17; Osterhaus, Experiments with Plants, page 138.

EXERCISE 40.

Object: To determine if air is essential to plant growth.

Materials: Tumblers or tin cans, jars, various kinds of seeds including sunflower and two potted plants. (Do not use valuable plants).

Directions: (1) Sprout beans, peas and sunflower under water. Check results by a lot on blotting paper and one in water boiled to drive air out. Remove shells carefully from sunflower seeds and germinate in boiled water which fills a bottle up to the tightly fitting rubber stopper.

(2) Grow potted plant with water covering soil and germinate seeds in tumblers or tin cans with soil completely saturated.

(3) Grow potted plant in a sealed jar for a short time.

EXERCISE 41.

Object: To determine if heat is essential to plant growth.

Materials: Moss, tumblers, seedlings of various plants, beans, peas, corn, turnip, etc. Growing slips of geranium or coleus.

Directions: (1) Freeze moss and note if growth is stopped. Immerse a second lot in boiling water and note growth.

(2) Invert tumbler over various seedlings and note effects.

(3) (For advanced students). Determine best temperature for growth of bean, pea, geranium, etc.

EXERCISE 42.

Object: To determine if light is necessary for plant growth and the influence of direction of light upon the growth directions of root, leaf and stem.

Materials: Various seedlings of different kinds of plants, bean, pea, corn, etc. Young plants of geranium or coleus.

Directions: (1) Grow pairs of plants, one in dark cellar and one in window. Record measurements and appearance.

(2) Compare potatoes sprouted in window with those sprouted in cellar. Visit a forest and notice how on the edge of the woods, the large limbs are on the side next to the open

field, while those within the forest have long smooth trunks. Does this habit of growth have any economic bearing?

(3) Expose geraniums or coleus to the light of a window taking care that all the illumination comes from one side. Note effect and compare with similar plant having light from all sides.

(4) In Exercise 41 (2) is light a factor?

(5) Tie white screen cloth over a tumbler and upon this place several sprouted peas. Place in shoe box lined with black cloth or paper and in one end cut a circular opening the size of a silver dollar. In this place a piece of paper in the form of a tube to admit light.

EXERCISE 43.

Object: To determine if water is necessary for plant growth.

Materials: Small plants of any kind, flower pots and germinating dishes if available, chalk box, cotton.

Directions: (1) Take two tin cans or pots in which plants are growing, (corn will answer). Put under like conditions except that water is withheld from one. Note effects.

(2) Investigate cacti, corn and some aquatic plants and determine upon what the amount of water used by the plant depends.

(3) Have hydroptism shown by fastening pea seedlings by means of rubber bands to the round surface of germinating cups or to surface of small flower pot. Immerse lower end in water and cover with closed flower pot. Fill a chalk box with moistened cotton or filter paper and cover with wire or cloth screen. Fasten upon this screen several sprouted peas with caulicles ¼ of an inch long. Invert the box and set at an angle of forty-five degrees. Note growth of the peas and show how it illustrates hydroptism.

(4) Repeat Exercise 28 if conclusions cannot be drawn.

References: Osterhaus, Experiments with Plants, pp. 95-99.

(5) Plan a field trip and make lists of plants according to location, viz., pasture plants, field plants, swamp or marsh plants, lake shore plants, etc. Does amount of moisture tend to make plant societies?

EXERCISE 44.

Object: To determine the effect of different kinds of soils and fertilization upon plant growth.

Materials: Different kinds of garden seeds, boxes or four-inch pots, filled with sand, fertile loam, clay, peat, subsoil and sawdust.

Directions: (1) Plant seeds in different kinds of soil and expose as nearly as possible to the same conditions. Determine which thrives best.

(2) Fill seven four-inch pots or boxes with pure sand. Add plant food as follows:—

1. Nothing.
2. Ten grams lime.
3. Ten grams lime, one gram potassium sulphate or chloride.
4. Ten grams lime, one gram acid phosphate.
5. Ten grams lime, one gram nitrate of soda.
6. Ten grams lime, one gram each of the compounds used in numbers 3, 4, 5.
7. A half pint of manure.

Thoroughly mix the materials with the sand and plant five or six grains of corn or beans in each. Record growth of plants, noting differences of color and the amount of growth.

References: Osterhaus, Experiments with Plants, page 139-160.

(3) Advanced students, or the teacher, may grow water cultures. Quart milk bottles may be used buried in sand to exclude light from roots. Fit tops with corks in which sprouted corn is wedged. Distilled water **must** be used. Prepare six bottles and add nothing to No. 1 except distilled water. No. 2 is to contain the complete nutritive solution as follows:—

A. Distilled water, 500 cu. cm.
B. Potassium nitrate, 0.5 gram.
C. Ferrous phosphate; 0.5 gram.
D. Calcium sulphate, 0.25 gram.
E. Magnesium carbonate, 0.25 gram.
No. 3, Omit B.
No. 4, Omit C.
No. 5, Omit D.
No. 6, Omit E.

Record growth of each and note differences. Make a list of the several **elements** necessary for plant growth. See Exercise 23. Remember that the supply of carbon comes from the carbonic acid of the atmosphere.

Reference: Strasburger, A Textbook of Botany, page 173.

EXERCISE 45.

Object: To determine if a plant gives off or transpires water.

Materials: Young plants of geranium or coleus, peas, box of sawdust with one side fitted with pane of glass.

Directions: (a) Lay a plant with straight stem upon its side and notice any change. Is light a factor? If so, aim to overcome it.

(b) Plant sprouted peas next to glass in jars or olive bottles in various positions and watch their growth. A box with glass front is best if it can be obtained.

EXERCISE 46.

Object: To determine if a plant gives off or transpires water.

Materials: Two or three geraniums, corn, or bean plants. Glass dish or bell jar.

Directions: (1) Pot a plant in tight tin can and pour melted paraffin over soil, in order to stop any loss of moisture therefrom. Weigh carefully and determine loss of moisture, if any. A small opening may be made in the paraffin and plant watered by means of a funnel, weighing carefully the water used. In this way the trial may be carried on indefinitely and rate of transpiration determined under varying conditions of light and temperature.

(2) Cover a small plant with glass dish or bell jar and note deposition of moisture.

(3) Compare geranium leaves when one has its petiole (stem) in water and the other has its blade in water. In order to help answer the question how water enters the plant immerse stems in red ink or eosin solution for two or three hours and examine by cutting cross sections of stems. Treat a carrot or parsnip in the same way and then answer the question.

EXERCISE 47.

Object: To illustrate the habit of the growth of plant roots.

Materials: A field or garden, pick ax, shovel, sharp stick, a tin or iron quart dish, several buckets of water, a well developed corn plant.

Directions: Dig a hole about 6 feet long and 3 feet wide, 5 to 6 feet deep, close to the plant, letting one side come about 4 or 5 inches from the base of the plant. The hole should run crosswise, not lengthwise, of the row. Pour water from a pitcher about the base of the plant and wash away the soil from the roots, gently loosening the soil with a stick, thus hastening the work. Then carefully expose the roots along the side of the wall, tracing them as far as possible laterally and as deep as may be, taking care to loosen as little as possible from their natural position. In what part of the soil are most of the roots? How deep do they penetrate? How near do they come to the surface? How far do they reach out from the parent plant? Corn roots usually penetrate the soil 4 or 5 feet deep and many extend within 2 inches of the surface. Only a few will be found where the soil has been plowed or cultivated. What relationship do these facts have upon the effect of deep plowing and of shallow cultivation? How deep should the soil be disturbed between the rows? What relationship does the wide spreading of the roots, 5 or 6 feet from the parent plant, bear to the application of fertilizers? Should fertilizers be put simply in the row or hill, or spread uniformly throughout the surface soil?

Crop Studies.

EXERCISE 48.

Object: To determine the composition of plant tissues.

Materials: Dry beans, potatoes or apples and lettuce heads.

Directions: Take 75 or 100 grams of raw potato, cut in thin slices and steam thoroughly for two or three hours to kill the individual cells. Take care that water is not allowed to come in contact with the potato so as to wash out some of the starch. Dry in oven until the weight is constant. Determine percent of water. Grind up some beans and subject to same process and also treat lettuce in the same way. In one trial the water content in potatoes was 81%, in beans a little over 11% and in lettuce over 97%. For advanced classes the dry products may be placed in iron dishes and the carbonaceous

matter burned. Add a small amount of boiling water and bring contents of dish to a boil. Filter and evaporate filtrate to dryness and weigh. Result will be amount of soluble ash. Dry residue and filter paper, ignite and weigh, and result will be amount of insoluble ash.

EXERCISE 49.

Object: To familiarize the student with the legumes.

Materials: At least three of the following legumes: red clover, alsike clover, alfalfa, black medic, sweet clover, hairy vetch, field peas.

Use fresh specimens if possible, but dried specimens may be used which have been dug up and tied in bundles without pressing. Study and describe with the aid of the following outline:

Leaves. Spirally arranged; two-rowed; abundant; medium; not abundant; oval; elliptical; cordate; obcordate.

Leaflets. Number; palmate; pinnate; smooth; hairy; edges smooth; serrated.

Leaflets. Sketch; length; width.

Midrib. Ending in leaflet; ending in tendril; neither.

Stipules. Sketch; attached to petioles; not attached to petioles.

Stems. Height; diameter one inch from base; erect; spreading; decumbent; trailing.

Stems. Round; square; hairy; smooth; stoloniferous; not stoloniferous.

Branches. None; few; many.

Inflorescence. At end of leaf-bearing stem or branch, springing from axil of leaf.

Inflorescence. Raceme; umbel; capitulum.

Flowers upon maturity. Reflexed; not reflexed.

Calyx. Length of anterior tooth compared with other teeth.

Petals. United; free; white; red; pink; purple; blue; yellow; persistent; not persistent.

Prepare a paper upon the "Value of the legumes as forage crops."

References: Bergen. Elements of Botany.

EXERCISE 50.

Object: To enable the identification of the most common grasses by means of their heads and leaves.

Materials: Dried bundles of the various grasses. Heads of the principal grasses preserved in 3 percent formalin are excellent for study.

Include timothy, barn-yard grass, June grass, orchard grass, red top and the foxtails.

Directions: With Vt. Exp. Sta. Bulletin No. 94 in hand, describe head and leaf of each grass as fully as possible. Get the general characteristics. Correlate this with a field trip identifying as many kinds of grass as possible and complete description in notebook, noting kind of soil preferred by each, relative amount of moisture, etc. Make a list of pasture grasses, dry meadow, wet meadow, and sand grasses.

EXERCISE 51.

Object: To enable one to identify the most common weeds by their seeds.

Materials: Small vials containing weed seeds which have been collected from year to year by previous classes.

Directions: In fall take a field trip and collect seeds of various weeds. These may be partially cleaned and put into small vials, properly labeled, for reference. Put up a duplicate set without label, but with number corresponding with the original set, for class use. Make lists of roadside weeds, pasture weeds, meadow weeds, etc.

With Vt. Exp. Sta. Bulletin 94, Nevada Exp. Sta. Bulletin 38 and Mich. Exp. Sta. Bulletin 260, most of the weed seeds may be identified.

EXERCISE 52.

Object: To identify various legumes and forage crops by means of their seeds and heads.

Materials: Select and preserve in 3 percent formalin the whole fruit (head) of as many of the legumes mentioned in Exercise 49 as possible. Copy of Vt. Exp. Sta. Bulletin 94 for each member of class.

Directions: Study at least three, including red clover. The following outlines may be used, and when adjectives do not apply others may be suggested.

Calyx. Number of teeth; relative length of inferior tooth, persistent; easily removed.

Calyx tube. Hairy; smooth; number of ribs.

Corolla. Number of petals; free; united; persistent; easily removed; smooth; hairy.

Pod. Roundish; kidney-shaped; elongated; straight; twisted; opens longitudinally; opens transversely.

Style. Persistent; deciduous.

Seeds per pod. Extreme numbers; usual number.

Threshing. Seeds easily removed; seeds difficult to remove; reason.

Seed. Viewed from two largest diameters; round; oval; elliptical; kidney-shaped.

Seed. Viewed from two smallest diameters; round; oval; flat.

Seed. Orange; yellowish brown; yellow; reddish; red; green; yellowish green; dark olive-green; black.

Hilum. Round; oval; elongated.

Radicle. More than half the edge; half the edge; less than half the edge.

Radicle. Tip prominent; tip not prominent.

Reference: Hunt: Cereals in America, page 151-52.

EXERCISE 53.

Object: To recognize the different kinds of buds.

Materials: Twigs of apple, plum and cherry.

Directions: Study the external appearance of the buds and note any difference in appearance; then cut longitudinal and cross sections and find pure leaf buds, fruit buds, and mixed buds. If care is taken, the miniature flowers in the fruit buds may be seen. Place twigs in water to watch their development. Horse chestnut buds are excellent for bud study when available.

EXERCISE 54.

Object: To note variations in any crop with a view to selection for ultimate improvement of stock.

Materials: Spring balance, pail, spading fork or hoe.

Directions: Obtain permission to go into a nearby potato field and dig twenty hills or more. Weigh and count the large (marketable) and the small potatoes. Tabulate results according to the following:

Hill	Large		Small	
	Number	Weight	Number	Weight

Note the variation in individual hills. Considering the sum total of good points for each hill, which hill would be the most desirable for seed? Should only large potatoes be used for seed? If used, would there be small potatoes?

In noting different hills, does a change in environment affect variation? May cultivated varieties be improved by proper selection? What are the best methods for selecting tomato seed or seed corn?

In the same manner study variation in peas and beans.

References: Hunt: Cereals in America, p. 14-26. "The Influence of Environment on the Origination of Plant Varieties", Year Book of the Department of Agriculture 1896, "Hybrids and their Utilization in Plant-breeding", Year Book 1897. "Improvement of Plants by Selection", Year Book 1898.

EXERCISE 55.

Object: Same as for Exercise 54, (variation in corn).

Directions: Visit a nearby corn field and have each student study ten hills, noting number of stalks in each hill, the number of suckers, of ears, of barren stalks and the average number of ears per stalk. If corn is planted in drills instead of hills similar facts may be noted.

Obtain data for the following table:

	1	2	3	4	5	6	7	8	9	10
Height of 10 stalks....	...	...	...	...	...	...	...	...	...	...
Height of ear.....	...	...	...	...	...	...	...	...	...	...
Length of shank of ear	...	...	...	...	...	...	...	...	...	...
Length of ear.....	...	...	...	...	...	...	...	...	...	...
Direction of ear.....	...	...	...	...	...	...	...	...	...	...
Number of leaves.....	...	...	...	...	...	...	...	...	...	...

What are suckers? What is a shank? What is the usual direction of the ear, and what effect upon its direction does a long slender shank have? Notice the great variations in different plants. To what extent are these variations hereditary? What are other causes affecting variation in the character of the ear? From what kind of ear should seed be selected? What uncertainty concerning the ear? What may result from pollen coming from a poor stalk?

Reference: U. S. Dept. Agr., Farmers' Bulletin, No. 229.

EXERCISE 56.

Object: To show how to propagate certain common plants.

Materials: Stems of currant, gooseberry, grape, geranium and leaves of begonia. Copies of U. S. Dept. Agr., Farmers' Bulletins 157 and 218 for each student are very useful.

Directions: (1) Have students make the cuttings in each case and have some of these planted in boxes in the schoolroom and upon the school grounds or school garden. Encourage students to grow such cuttings at home.

References: U. S. Dept. Agr., Farmers' Bulletins 157, 218.

(2) Exercise in budding. This is an optional exercise and unless there is plenty of time it better not be attempted, as it has to be done in early September.

Same references as above.

(3) Exercise in grafting. Have each pupil make several root grafts. Always graft from desirable varieties. These

may be taken home by students and grown in home orchard or garden.

(4) Exercise in pruning. Have several hand saws and sharp jack-knives. First determine the principles of pruning and objects desired, then obtain permission to prune some neglected orchard.

References: "The Pruning Book", L. H. Bailey, Macmillan Co.

EXERCISE 57.

Sundry Suggestions.

This work should be persistently followed up throughout the year remembering that the value of a collection depends upon its attractive arrangement and proper labeling. Suitable cupboards will be provided if valuable collections are once collected.

(1) Have the common grasses collected and tied in bundles properly labeled. A label should contain the scientific name, the common name, place, locality, date and name of collector. Example: *Phleum pratense*, timothy or herdsgrass, Montpelier, upland meadow, July 16, 1911. A. B. Brown. Have seeds of each of the grasses placed in small vials and labeled.

(2) Do the same with the grains.

(3) Follow the same with the common weeds.

(4) Have collections made of the leaves and fruits of the trees and shrubs of Vermont. This may be supplemented by making a collection of twigs before the buds open and of the different woods.

Reference: Vt. Exp. Sta. Bulletin, No. 73, "The Trees of Vermont", 146, "Vermont Shrubs and Woody Vines."

Field Trips.

(1) Notebooks should be taken on all field trips and if possible the entire afternoon, or if this cannot be done, from three o'clock to five-thirty, should be employed.

Study plant societies, viz., pasture, woodland, swamp, bog, meadow, dry, sandy soil, etc.

(2) Study forest conditions; determine if lumber is in prime condition to cut. What kind of trees has past treat-

ment favored? Make a list of the trees and estimate percent of each on acre. Estimate number of board feet on an acre. Visit land suitable for reforestation and study methods. (See Exercises 58-64).

(3) Make lists of plants as found on particular soils, as clay, sand, rich loam, etc.

(4) Study plant diseases. Students should be taught to recognize the most common of fungus diseases. Call their attention to the way in which fungi are propagated by spores. Compare with bread mold which may be studied profitably.

References: Mass. Exp. Sta. Report, 9, p. 57. H. Marshall Ward, Diseases of Plants.

(5) Study of insect enemies. Learn to recognize the insect enemies of plants which are the most destructive. Study the different stages in life of each. Note those injurious to plant by chewing and those that suck the juices. The subject of spraying with bordeaux mixture may be taken up and used for a special exercise. For directions, consult Vt. Exp. Sta. Bulletin 113.

Miscellaneous.

(1) Have students find number of cubic feet and weight of one bushel of corn on the cob. Repeat with shelled corn. What part of a bushel will a bushel of corn on the cob make when shelled?

(2) Measure hay in mow to find number of tons.

(3) Protection afforded by corky covering of plants. Select two potatoes and two apples of equal size. Pare one and obtain weights of both. Hang over stove and weigh every day. Tabulate results and compute percent of total weight lost. Another student may place his under ordinary room conditions. What does this teach about care of apples and potatoes and value of potatoes cut by hoe in digging? If loss from unpared potato is less, give reason. Upon what does the usefulness of the potato depend? What is the use of the pulp of the apple to itself?

(4) For advanced classes find effects upon growing plants of various strengths of salt solutions. Start with 1 percent solution and work down to more dilute solutions.

FORESTRY.

Forestry is a subject which cannot satisfactorily be studied out of a book or in the laboratory. The teacher should take the students for field excursions or assign definite periods for outdoor study. Many questions will arise which are not mentioned in these few exercises, whose only purpose has been to start the students thinking along forestry lines. It is not enough in our nature studies to create a love of the forest. That is inborn with every child, but when he becomes a land owner he is forced by the struggle for existence to treat his forest as an income producer. It is, therefore, important that the young generation understand the fundamentals underlying forest growth, so that they shall consider the forest as a crop to be harvested and grown again and not as a mine or a quarry to be exploited and abandoned.

Exercises 58 and 61 will necessarily have to be studied in the spring; 59 and 60 in the fall; while the remainder may be taken at any time most convenient for getting into the woods.

EXERCISE 58.

Object: To learn the tree flowers.

Directions: Watch the trees of your region in the spring to see if they have flowers of any kind. Make a list of the trees in the order in which their flowers appear. Describe or draw the different flowers. Do you see any resemblance between the flowers of different trees as the birch and poplar? If so, what trees have similar flowers? If correctly noted, this will show which trees are related. Look particularly for the small flowers of the pine, spruce, or tamarack.

Reference: Vt. Exp. Sta. Bulletin 73, "The Trees of Vermont."

EXERCISE 59.

Object: To learn the tree seeds.

Materials: Collections of different kinds of tree seeds, pine cones, etc.

Directions: Some trees ripen their seed in the spring, but most of them in the fall; so the latter (September or October) is the best time to study this exercise. What trees have nuts? Under pine and spruce trees you may find cones. These are not the seed, but the seed grow in the cones. If you

do not find any seed in the cones you have collected, climb the tree and pick some cones that have not opened. Dry these out in the sunlight of the window and note the seeds. Where are the seeds in the cone and how many of them? Why were there no seed in the dry cones on the ground? How would you go to work to collect a lot of seed of spruce, birch, ash and oak?

Reference: Vt. Exp. Sta. Bulletin 73, "The Trees of Vermont."

EXERCISE 60.

Object: To study tree seed distribution.

Directions: In the fall go into a pasture where there are a few scattered butternut or beech or hickory or other nut trees. Notice how far away from these trees you find the nuts. If it is on a hillside, how far down the hill do the nuts roll? You may find a pile of nuts hidden somewhere. If so, who collected them? Go into the woods when the wind is blowing in the fall and try to find some seeds being carried by the wind. You will notice that some of them twirl around in the air and seem to sail farther than others. What makes this? What kind sail farthest? Out in the pasture on the edge of the woods, how far from the woods can you find the seed of maple and ash? On a pleasant day after the first fall of snow in the fall, go into the woods and try to find tree seeds on the snow. What do you find the most of? Is it because there are more large trees of that kind, or because the seed is more plentiful and can be blown long distances? If this happens every year you would expect a great many little trees of this kind.

EXERCISE 61.

Object: To study tree seed germination.

Directions: This exercise should be studied in the spring. If there is a cider mill near you, visit the pile of pulp in May or June and see if you find anything growing on it. Get down on your hands and knees under the old maple tree by the roadside and try to find some little maples. Do you find many? What becomes of them? Why don't they grow up? Go into the sugar orchard and see if there are little maples there that are growing up into good trees to take the place of the old ones. If not, why not? If you have a pond or lake or river near you, go along the shore and see if you find any forest seedlings coming up just above the water line. What kind

are they and why should they grow here? Find an old decayed log or big stump in the woods. Is there anything growing on it? Sometimes you will find a straight row of big trees that started in that way.

EXERCISE 62.

Object: To show the height growth of trees.

Materials: Rule, paper and pencil.

Directions: Go where there are some young spruce or pines growing. Select some that are not too tall. Note that the limbs grow in whorls at different heights. At the top of the tree will be found a cluster of buds. What relation have these buds to the whorl of limbs? How can one determine the age by the whorls? Note the age and height of ten trees. With the ruler measure the last year's growth; that of 1 year ago; 2 years ago, etc. Which year did the tree grow the most? Find this out for several trees. Was it always the same year or different years? What was the greatest growth made in a single year?

EXERCISE 63.

Object: To show the diameter growth of trees.

Materials: Ruler, paper and pencil.

Directions: Go to some woodlot which has been recently cut and where the stumps were sawed off so that the rings show plainly. Note which kind of trees have rings that are easiest to count. Count the rings on ten trees of one kind but of different diameters making record of the diameters and ages. Are the oldest trees also the biggest in diameter? Is the rate of growth uniform throughout the age of the tree? If not, can you think of any reasons for a change? At what period in the life of each tree did it make the most growth? During the past ten years do you find that any one year was particularly favorable to diameter growth? If so, does it correspond to the year that the trees made a good height growing in Exercise 62?

EXERCISE 64.

Object: To show basal area of growth of trees.

Materials: Ruler, paper and pencil.

Directions: Go to the same place as last exercise or a similar cutting. Find the diameter of one tree at the age of 20, again at 30, 40 and 50. The diameter can be considered as

twice the radius. Take all the readings on the same radius. Subtract the diameter at 20 years from that at 30 and divide by the diameter at 20 to get the percentage of growth. Do the same for the other ages. What was the area of the cross section at 20, 30, 40 and 50 years. Get this by the formula: A equals R^2. Obtain the percentage of increase of area as of diameter and compare the two. This gives an idea of how rapidly a tree grows.

EXERCISE 65.

Object: To make observations at the saw mill.

Materials: Ruler, paper and pencil.

Directions: Visit a saw mill if you can get permission. Watch the man who handles the log and saws off the boards. He is the sawyer, and is paid more than the other men, because he has to know the best way to saw up a log. Notice that when a new log goes in, he first saws off slabs with the bark. In some mills the sawyer cuts these slabs off the four sides and makes a square log first; in others he saws the boards off the round log. In the first case the boards will be square edged; in the second, they will have bark on the edges and are called round edged. Which way does your sawyer do? What kind of logs have the greatest waste in slabs? What other form of waste is there? Did you notice any part of the trees wasted in the woods? The sawyer usually marks a number on each board as he takes it from the saw—what does this mean?

EXERCISE 66.

Object: To study the rotting of wood.

Materials: Paper and pencil, ax or hatchet.

Directions: Find a place where some trees have been recently cut; or secure permission and cut down one or two trees. Note the difference in color between the wood in the center of the tree and that near the outside. Which is the heart wood and which sap wood; and which is the drier? Which part do you think would last longest? Find, if possible, an old fence post or clothes reel that has been taken out of the ground. What part of it rotted most; heart or sap; above or below the ground? What kind of wood are most of your fence posts? What kind is used for railroad ties? In the woods find some old logs that have been on the ground a long time. Cut into them with your ax. Do you find any of these sound inside? If so, what kinds?

ANIMAL LIFE.

EXERCISE 67.

Object: To familiarize students with the common nutrients in animal and human foods.

Materials: (1) A piece of lean meat, the white of an egg, a piece of cheese (preferable skim-milk cheese or Edam cheese), "gum" made by chewing wheat kernels.

2. Sugar, starch, a piece of linen or cotton cloth.
3. Butter, lard, olive oil.

Directions: The materials listed above are:

1. **Proteids.** Flesh makers.
2. **Carbo-hydrates.** (Carbon and elements of water). Heat producers, source of fat storage and formation.
3. **Fats.** Heat producers, source of fat storage.

Learn to recognize each. Make simple tests of recognition as follows:

1. Burn a feather, hair, wool; note the characteristic odor, different from that of burning starch, for example.
2. Boil starch in water and starch a cloth. Boil flour, oatmeal or potato, and note if the product will starch a cloth.

Drop a drop of iodine into a starch solution. What happens? The reaction denotes the presence of starch. Try it in a cold solution; then warm it gently.

3. Make a grease spot on clean white paper. Drop a drop of ether on it and let it evaporate.

Whether it is a boy or a cow that is being fed; whether the meal consists of soup, meat, and pie, or hay, silage and grain; boy and cow alike eat and digest proteids, carbohydrates and fats. These nutrients are what keep us alive and warm, and enable us to work.

References: Vt. Exp. Sta. Bulletin, 144, "Concerning Feeding Stuffs"; 152, "Principles and Practice of Stock Feeding."

EXERCISE 68.

Object: To teach how to formulate a balanced ration.

Materials: Vt. Exp. Sta. Bulletin 152. A collection of the more common hay grasses, cereal crops, forage crops and the more common grain feeds sold in the community.

Directions: In order that an animal should be properly nourished and do profitable service, it is necessary that it

should have ample supplies of food of the right kind and that the nutrients should be fairly well proportioned. A cow, for instance, cannot make the curd of her milk out of starch. She must have protein, and if she is stinted in the supply of that nutrient which is needed to make this portion of milk, she simply cannot make milk, any more than figs may grow on thistles. The supplying of a ration which will afford a given animal the right amount and the right proportions of the several nutrients, is termed the furnishing of a "balanced ration." Different amounts and different proportions are fed to different animals for different purposes. The rations used in fattening an ox or a hog, for working or for trotting horses, to make a cow give a large mess of milk, or a hen to lay a lot of eggs; all these differ. They contain the same nutrients, but in different proportions.

There are a multitude of good combinations of the roughages and concentrates for various kinds of feeding. By the use of the tables in bulletin 152 of the Vt. Exp. Sta. and the printed matter descriptive of their use one can formulate a balanced ration which is likely to be satisfactory. (The directions will be readily found in the bulletin in question for it is thoroughly indexed. The matter on pages 37 to 44 of bulletin 144 will be found of service in this connection.

References: As above: Also U. S. Dept. Agr., Farmers' Bulletin 22, "The Feeding of Farm Stock."

EXERCISE 69.

Object: To test milk for its butter fat content.

Materials: Babcock tester and outfit, sample jars (lightning fruit jars to be preferred), samples of milk.

Directions: Steps in the process:

1. Sampling.
2. Preparation.
3. Pipetting.
4. Adding acid.
5. Whirling and water adding.
6. Reading.

1. **Sampling.** Mix the milk (entire milking) by pouring back and forth at least thrice, sampling immediately. Composite sample is advised. See item 2 in exercise 70.

2. **Preparation.** Shake sample in jar gently to loosen cream that may stick to the sides of jar. Remove cover. Pour backwards and forth several times, at least thrice.

3. **Pipetting.** At once draw milk into pipette to point above the mark in the neck and place the finger on the end to hold it. Loosen the finger slightly till the level lowers to the mark, "17.6 c. c." Run the milk into the test bottle, held at an angle, blowing out the final drops.

4. **Adding Acid.** Fill the acid measure to or slightly above the mark with sulphuric acid. Pour it carefully and slowly into the bottle, holding the same at a slant. Then mix the contents by a rotary motion, the mouth of the bottle being held away from the face, until all the curd has disappeared, and for sometime thereafter. Do not mix insufficiently, but take plenty of time shaking the bottle. If the acid is spilled on the clothes, person, table or elsewhere, drench with water. Always have plenty of water close at hand in case of accident.

5. **Whirling and water adding.** Place the bottle in the centrifugal, balancing with a similar bottle (filled) on the opposite side. Whirl at the stated speed (700-1200 revolutions per minute according to the make of the machine) for an interval of at least 5 minutes. Stop the machine, and add boiling hot water to the bottle until the fat is raised to the base of the neck. Whirl again for 2 minutes. Add boiling hot water with care to bring the fat into the neck. Whirl for one minute.

6. **Reading.** The reading is accomplished by the subtraction of the bottom reading from that of the top, taking the latter from the top of the curve. The reading should be made at once while the contents are hot. There should be provision made for keeping the contents of the tester hot during the operation (hot water, steam, oil stove, or otherwise).

7. **Cleaning.** Empty bottles promptly. Rinse with hot water containing washing powder to cut the grease. Rinse again with clean hot water.

For more detailed explanations (which are important, for the above is a bare outline and does not dwell on many of the details to the extent that their importance merits), see the book of directions issued with each tester by manufacturers.

If the school does not own a Babcock, borrow from a creamery or a farmer. Perhaps neighboring schools can club together in its purchase.

References: Books of directions issued by manufacturers of apparatus; N. H. Exp. Sta. (Durham, N. H.), Bulletin.

EXERCISE 70.

Object: To test cows as to their dairy abilities.

Materials: Scales, record sheet, Babcock outfit.

Directions: 1. Weigh the milk three days monthly and at the end of the year add the records and add a zero at the end for the year's record.

2. Sample (composite sample, 4 to 8 consecutive milkings, preserved with formalin or corrosive sublimate) twice or thrice a year as suggested by the Vt. Exp. Sta. Bulletin 128 (which see for directions).

3. Test the sample (See exercise 69).

4. Multiply weight by test, dividing by 100. This gives butter fat in pounds. Multiply by 1.1-6 for butter.

5. Example: 12 months record weights=426 lbs. 426 x10=4260. Average test 4.6. 4260x4.6÷100=186. 186x 1.1-6=217.

What is the use of weighing milk? What is the use of testing milk? Can one tell from milk weight alone the worth of a cow? Why not? Can you tell from milk test alone the worth of a cow? Why not? Can one tell from both the worth of a cow? Why not? What other factor is needed? Is it easy to keep food records? Is it not practicable to keep records with one's cows? Do all cows make a profit? Do many make losses? Can you tell the one from the other by their looks or surely in any other way? Is not knowing what they do in terms of pounds of milk and butter and what they eat in terms of pounds of food better than going it blind? Of what use is it to keep cows which do not pay their board bills?

6. Compare cows thus tested.

Urge neighboring farmers to form a cow testing association. There are 11 such in operation in Vermont with over 6,000 cows under test. There ought to be ten times as many. Write to Hon. O. L. Martin, State Commissioner of Agriculture, Plainfield, Vt. for free bulletin on this subject.

References: Vt. Exp. Sta. Bulletin 128, "The Testing of Cows"; Vt. State Com. Agr. Bulletin on "Cow Test Associations."

SCORE CARD FOR POTATOES.

Will they be Profitable?

(From the Farmer's Standpoint.)

I. Will They Yield Well? i. e., Produce Well .....25 points

1. SIZE OF TUBERS. Individual potatoes should be fairly large, indicating strength and constitution.

2. NUMBER IN THE HILL. Hills with only a few good sized potatoes are undesirable, also hills with a large number of undersized potatoes.

3. COMPACTNESS IN THE HILL. They should be compact enough to gather easily, and spread enough not to push out of the ground.

II. Will They Sell? i.e., Are They What the Market Demands and Are They Attractive in Appearance .....25 points

1. SIZE. Potatoes should be large and of uniform size.

2. SHAPE. Tubers should be similar in shape and free from deformities and irregularities.

3. SKIN. Skin should be firm, clean, bright and clear, uniform in color. A white skin, other things being equal, is preferable.

4. SOUNDNESS. Potatoes should be free from scab, rot, sunburn and bruises, also from damages due to bad handling. They should not be hollow.

III. Will They Cook Well and Economically?.....25 points

1. MEALINESS. When boiled and baked. Potatoes which are immature, large and coarse or with a thin papery skin, and also those grown in heavy, wet clay soils are liable to be soggy.

2. COLOR WHEN COOKED. They should have uniform, white color throughout

and should not turn yellow or dark upon standing. Potatoes should be free from brown or blackish spots, and from dark or reddish streaks, especially near the stem and under the eyes.

3. EVENNESS IN COOKING. The different potatoes and the parts of each potato should cook quickly and uniformly. Potatoes which are hard and watery when cooked, or those having hard watery spots, or with a tendency to be yellow, will cook unevenly.

4. FLAVOR. They should have a sweet pleasing taste. Sunburned, sprouted, immature potatoes, or those which have been exposed to the light, will have a bad flavor.

5. EYES. Deep or sunken eyes, and those protruding in clusters, are objectionable, and cause a large loss in preparation for cooking.

IV. Do They Show Breeding?.....25 points

1. TRUENESS TO TYPE. Indicated by the uniformity in size, shape, color and other characteristics of the tubers.

2. FREEDOM FROM MIXTURE. A mixture of varieties is objectionable, because of difference in manner of growth, time of ripening and in keeping and storing qualities.

SCORE CARD FOR MOST VEGETABLES.

Form—Should be smooth, regular and correct for variety..15

Size—Moderate to large, but not overgrown.....10

Color—Characteristic of variety when mature.....20

Uniformity—All specimens in an exhibit should be uniform in size and color 20

Quality—Determined by appearance only.....15

Freedom from blemishes—discount for blemishes of any kind 20

Score Card for Cheese.

Flavor 50, texture 25, color 15, finish 10, total 100.

Score Card for Butter.

Flavor 45, body 30, color 10, salt 10, package 5, total 100.

UNIVERSITY OF VERMONT AND STATE AGRICULTURAL COLLEGE.

Score Card.

FOR JUDGING DAIRY CATTLE.

General Apperance, 10.

Age, estimated,....years; corrected,....years; weight, estimated,....pounds; corrected,....pounds; form, spare, light fore-quarters, triple wedge-shape..... 7
Quality, skin rather loose, thin and mellow, hair fine and soft with abundant, yellow secretions..... 3

Head, Neck and Fore-Quarters, 20.

Muzzle, mouth and nostrils large..... 1
Eyes, prominent and bright, with gentle, quiet expression 1
Face, clean cut and lean..... 2
Forehead, broad and dished..... 1
Neck, long and lean, clean at the throat making abrupt juncture with the shoulders..... 5
Withers, thin and prominent..... 5
Shoulders, light and oblique..... 2
Crops, spare fleshed..... 1
Legs, short and straight with fine shanks..... 1

Body, 30.

Chest, sufficiently developed to insure good vital capacity 2
Ribs, long, broad, open and well sprung below..... 2
Back, straight with prominent open spines..... 2
Loin, broad and spare..... 2
Flank, thin and high arching..... 1
Abdomen, long, broad, open and well sprung below....12
Abdominal muscles and navel well developed..... 2
Milk veins, long, tortuous and branching, prominent.. 3
Milk wells, well forward, large or numerous..... 4

Udder and Hind-Quarters, 40.

Udder, large size and capacity, elastic..... 6
Fore-udder, extending well forward, full in form..... 8

Hind-udder, well up behind, full in form and elastic	6
Teats, convenient and uniform size, squarely placed and well apart	5
Hips, prominent and well apart	2
Rump, long and level, wide and roomy pelvis	4
Thurls, wide apart and high	1
Thighs, long, thin, wide apart, incurving with open twist	6
Tail, long and fine with good switch	1
Legs, short, straight, wide apart with good shanks	1
	100

UNIVERSITY OF VERMONT AND STATE AGRICULTURAL COLLEGE.

Working Score Card for Dairy Cows of Any Breed.

The working dairy cow must have:—

1. Vigor and Health—indicated by.....20
   - deep chest
   - bright eye
   - active manner
   - loose elastic skin
   - oily hair
   - medium flesh
   - open nostrils

2. Capacity for taking food—indicated by.....45
   - large barrel
   - long, deep and wide
   - triple wedge shape

3. Milk giving disposition—indicated by.....35
   - being thin when well fed
   - loose structure (long tail)
   - large, loose udder
   - large branching milk veins
   - refined, feminine expression

100

REFERENCES.

Every teacher is urged to get and use as many of the following references as possible. The bulletins are, for the most part, free for the asking, and the books here mentioned may be secured at a nominal price.

Publication.	Author.	Publisher or Address.
Bulletins,	Vt. Experiment Station,	Burlington, Vermont.
Farmers' Bulletins,	U. S. Dept. of Agriculture,	Washington, D. C.
First Principles of Agriculture,	Goff & Mayne,	American Book Co., N. Y.
Agriculture for Beginners,	Burkett, Stevens & Hill,	Ginn & Company, Boston.
Elementary Agriculture,	Hatch & Haselwood,	Row, Peterson & Co., Chicago.
First Book of Farming,	Goodrich,	Doubleday, Page & Co., N. Y.
Elements of Agriculture,	Warren,	Macmillan Company, N. Y.
Practical Nature Study,	Coulter Patterson,	Appletons, N. Y.
Experiments with Plants,	Osterhout,	Macmillan Company, N. Y.
Soil Physics Laboratory Guide,	Stevenson & Schaub,	Orange Judd Company, N. Y.
Physics of Agriculture,	King,	(Madison, Wisconsin).
Soil,	Lyon & Fippin,	Macmillan Company, N. Y.

The first five of the above named books are well adapted to rural schools, at least for use of the teacher. The book by Hatch and Haselwood is very strong on application of arithmetic. The "Laboratory Guide" is adapted to schools having a good laboratory with some equipment, but contains much that may be modified and adapted to rural school conditions. The last two books in the list are intended for college work, but are valuable as reference books for the more advanced work in high schools.

Sundry pamphlets published by makers of farm machinery and fertilizers contain much that is distinctly helpful. In most cases these may be had for the asking.

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